Study on the Trends & Usage of Prefabrication and Modularization: Increasing Productivity in the Construction Industry

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Abstract
Climate change has emerged as one of the most pressing environmental issues in recent years. The construction industry contributes to the increase in the level of carbon dioxide (CO2) in many aspects. For example, the cement sector alone accounts for 5 % of global man made CO2 emissions. Manufacturing of raw materials (e.g. cement and steel) and chemicals have considerable impact on CO2 emissions.

Prefabrication systems are believed to have the potential for better environmental performance and have been adopted by the construction industry to meet the challenges posed by sustainable development.

Prefabrication has been developed since the 1970s. The technologies have been further developed and improved for the past thirty years. The successful implementation of quality control and construction efficiency has been addressed with support from the public sector. The technologies however did not receive attention from the private sector since prefabrication requires dimensional coordination and standardization in the designs. Discussions on effective implementation and increase in productivity of prefabrication have been discussed. The findings provide ameliorated understanding on the best practice of the implementation of prefabrication and provide for further improvement and implementation for the industry

1. INTRODUCTION
Prefabrication and modular construction are processes that have been used by generations of construction professionals. Over the past century, these processes have
developed a stigma of “cheapness” and “poor quality.” However, through modern technology, that image has changed. Prefabrication/modular construction has been around for many years, it is not unexpected that 85% of industry players today are using these processes on some projects—including 90% of engineers, 84% of contractors and 76% of architects.

Prefabrication and modularization are certainly not new to the construction industry. However, current influential construction trends, such as the increasing interest in lean construction, the rising use of BIM technologies and the growing influence of green construction have caused many practitioners to reconsider their appeal. In fact, the National Research Council’s 2009 report on improving productivity in the construction industry recommends prefabrication/modularization as an “opportunity for breakthrough achievement.” These factors, combined with recent advances in prefabrication/modularization, make this a critical trend in the construction industry.

2. THE TIME IS RIGHT NOW

Prefabrication/modularization has not had a steady increase in use over time; instead, it has fluctuated based on the level of drastic need during war and economic booms. However, technological advancements over the past 20 years have increased what prefabrication/modularization can achieve in the construction industry. BIM, quality modern materials and sophisticated manufacturing facilities now offer significant productivity gains on projects not possible before.

With a construction market facing acute shortages in onsite skilled labor and also where players are trying to be leaner, many believe the time is right now, more than ever, for widespread adoption of off site prefabrication/modularization solutions on a major scale in the construction industry.

There is absolutely no dispute to the idea that putting up quality structures that are reliable, stand the test of time, and are mindful of environmental demands is never an inexpensive venture. Doing anything right always means accepting that a certain expense is involved. However, urban planning and construction cost estimating consultants can be an important element in controlling costs, and even keeping them down.

While some structures benefit from being conceived and built onsite, in the traditional manner, not every building benefits from bespoke architectural planning and construction. Prefabrication is another tool in the arsenal of the construction cost consultant for certain types of structures. With a prefabricated approach, entire buildings can be built ahead of time, in pieces, like a massive jigsaw puzzle.
Because smaller pieces are being built for assembly into a larger whole, this allows the work to be done in smaller, controlled environments, protected from the elements, meaning work can continue at a fixed, uninterrupted schedule. With the proper planning, electrical wiring, and even insulation can be done ahead of time, all built into prefabricated materials can be carefully selected for their environmental friendliness.

Once the components are ready, it’s simply a matter of bringing them to the site where the actual construction takes place. Depending on the size of the building, a completed, functional structure can be put up in just a matter of a few days.

New materials, construction techniques and planning strategies are critical to more efficient, environmentally harmonious building projects. Concepts like prefabrication can play a role in these ambitions.

3. IMPACT ON PROJECT SCHEDULE

Prefabrication can yield time savings through the ability to conduct work simultaneously onsite and offsite, as well as helping with better coordination among different trades. In addition, less onsite staging, such as scaffolding, is frequently involved. Regionally, the ability to avoid weather impacts can reduce construction time. Site conditions factor significantly in the ability of prefabrication to impact schedule. A shorter project schedule is the most commonly reported productivity benefit of prefabrication/modularization, as well as the one with the largest reported payback. Additional time may be spent in the design phase on complex projects to coordinate the use of prefabrication and modularization. However, the time saved onsite typically reduces the overall project schedule.

![Pie chart showing the impact of prefabrication/modularization on project schedule](image)

**Fig. 1**: Total Impact of Prefabrication/Modularization on Project Schedule
4. CHALLENGES OF USING PREFABRICATION AND MODULARIZATION

Prefabrication offers adequate challenges to its users. Some of the most important challenges which should be prioritised and addressed are as follows:

EARLY COMMITMENT TO ENGINEERING AND DESIGN WORK: Researcher has shown that prefabrication/ modularization, the engineering and design work have to be completed before onsite construction can begin, as opposed to conventional construction where only a portion has to be completed. Since this requires a well-defined scope early in the planning stage, some owners see this commitment as inflexible and a constraint on their delivery strategy.

INCREASED TRANSPORTATION LOGISTICS REQUIREMENTS: Owners cite the key role of transportation logistics in determining the feasibility of using prefabrication/ modularization. Size and weight limitations, route restrictions, permitting requirements and the need for lifting equipment are factors that all need to be planned and coordinated before construction begins. Owners emphasize the need to pay attention to transportation costs. Several owners cited cases where miscalculations were made up front which resulted in a substantially costlier project in the end.

LIMITED NUMBER OF PROVIDERS: The universe of providers of components via prefabrication/modularization is fairly small compared to the universe of providers of other kinds of components. This limited range of sourcing options is seen as a constraint and a risk factor.

5. FACTORS DRIVING FUTURE USE OF PREFABRICATION/ MODULARIZATION

Lower project costs and project schedule improvements are the top drivers behind current users’ decisions to use prefabrication/modularization in the future. Other top factors driving future use:

- Project quality improvements
- Cheaper labor costs
- Project safety improvement
- Saving time
- Owner demand
- Competitive market advantage
The fact that owner demand is a significant influence factor suggests that with more owner education on the benefits of using prefabrication/modularization, more adoption is likely in the future. Better education and awareness as a driver for future adoption of prefabrication/modularization. This is currently needed, as it will help the industry as a whole understand the key benefits of prefabrication/modularization and ways it improves project productivity.

**Factors Driving Future Use of Prefabrication/Modularization**
Saving money is the top driver, identified by 77% of current non-users as a factor influencing their decision to use prefabrication/modularization in the future. These findings indicate that in this down economy, firms that decide to use prefabrication/modularization in the future are mainly concerned about what will help their bottom line and allow them to be more competitive. In the construction industry, where profit margins can be slim, any reduction in project time and cost can be critical. The fact that owner demand (66%) is a significant influence factor suggests that with more owner education on the benefits of using prefabrication/modularization, more adoption is likely in the future. The majority of firms (60%) also report better quality control as a significant driver, demonstrating that in a competitive market, being able to distinguish your product is highly important. Although it is not a top factor, 46% of firms see better education and awareness as a driver for future adoption of prefabrication/modularization. This is currently needed, as it will help the industry as a whole understand the key benefits of prefabrication/modularization.

Non-Users Current Reasons for Not Using Prefabrication/Modularization on Projects

The most important reason for not using prefabrication is the lack of knowledge about its application and feasibility. The studies suggest that 46% of the architects did not consider Prefab/Modular components in their project, while 34% are not familiar with the prefabrication process. In 26% cases the owner does not want Prefabricated Elements which can be definitely attributed to lack of knowledge or misinformation about the prefabrication system.

The findings suggest that the cost benefits of prefabrication/modularization are better known while there is still a need for understanding the processes and the wider applicability of prefabrication/modularization. Anecdotal evidence from owners demonstrates that various challenges exist, such as the need to commit to design work at an early stage and to figure out the logistics of shipping components to the site. However, once those obstacles are overcome, owners report that multiple benefits can be achieved in addition to schedule and cost improvements, such as increased safety, waste reduction and overcoming skilled workforce shortages.

6. BENEFITS OF USING PREFabrication

Prefabrication system has a large number of benefits compared to conventional construction processes. Some of the most important benefits are summarised as follows:

- Waste: Prefabrication in a controlled environment creates much less waste. Any stud material that is left over, any gypsum sheathing that is left over can be reused
for another project. The amount of waste is minimal as there is no off-cuts etc. as everything is already made to size. Use of prefabrication/modularization leads to less waste onsite and as a result less energy use.

- **Construction Waste**: The impact of construction on the environment is significant. The US EPA estimates more than 135 million tons of debris from construction sites end up in landfills in the U.S. each year. According to the industry, that waste can be effectively minimized through the use of prefabrication/modularization. Not only does prefabrication help mitigate construction waste and lead to a greener construction site, it can also reduce material use, increase recycling and allow for greener material selection.

- **Site Impact**: The lack of scaffolding reduced the site impact. Site safety increases as there are fewer site-based operations that happen on site.

- **QUALITY**: In the prefabricated panels minimizes deflection and thus helps the structural system.

Quality control and factory sealing and design can ensure high energy efficiency. Prefabricating components away from the site allows higher quality due to the controlled environment provided by the manufacturing facilities.

- **Costs**: Labor costs can also be a driver for prefabrication/modularization. Owners state that in areas where the local labor costs are very high, prefabrication/modularization offers a less costly alternative. Owners are able to shift some of the work to an off-site location and take advantage of cheaper labor costs.

- **SAFETY**: Almost all owners agree that overall project safety is improved through the use of prefabrication and modularization. The risk to owners from worker accidents and lost time is reduced when construction work is transferred away from the job site and into a controlled manufacturing environment. Types of safety addressed by prefabrication/modularization include less exposure to: Weather, Heights, Hazardous operations, Congested construction activities.

### 7. USING PREFABRICATION/ MODULARIZATION ON GREEN BUILDING PROJECTS

According to different studies, green projects comprised nearly a third of all new nonresidential construction activity in 2015, with that share expected to grow significantly over the next five years. Given this increase, it is important that the industry recognizes the contribution prefabrication/modularization can offer in meeting green goals. Use of prefabrication/modularization can help projects achieve LEED credits under the U.S. Green Building Council’s LEED green building certification.
program. However, there is still a majority that does not recognize that intersection. There are several ways prefabrication can contribute to a greener project—and potentially to LEED credits. Aside from the waste reduction benefits, off-site work could reduce habitat and site disturbance; protect some materials from rain and inclement

![Fig. 2 Impact of Prefabrication on creating a green construction site](image)

**8. SUMMARY**

With drastic changes in environmental conditions and ever increasing demand for reduction in CO2 emissions, prefabrication has offered significant advantages to the construction industry to address these concerns. Prefabrication can yield time savings through the ability to conduct work simultaneously onsite and offsite. Prefabrication has its own challenges which can be easily overcome by new technologies coordination. on the other hand, benefits that it offers are innumerable and highly significant. According to the studies, Prefabrication has a very bright future which is highlighted by sweeping transition towards its use. Awareness about the use and dedicated research efforts in prefabrication can make this transition successful and smooth.

**REFERENCES**


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